Mem. Natn. Sci. Mus., Tokyo, (37), December 25, 2001

Rugose Corals from the Kanoyama Limestone in the Kanto Mountains, Gunma Prefecture, Japan

By

Hisayoshi Igo[1)*] and Shuko Adachi[2)]

猪郷久義[1)*]・安達修子[2)]：群馬県叶山石灰岩の石炭系・ペルム系境界付近のサンゴ化石

Introduction and Geologic Setting

Upper Paleozoic limestones exposed in the Kanto Mountains are now interpreted as exotic blocks embedded in the Chichibu Group that constitutes the Jurassic accretionary complex (Chichibu Terrane). Fusulinacean foraminifers occur commonly in these limestones and have been repeatedly studied by many specialists because the fossils have generally been regarded as having high potential for dating. Rugose corals are less common but locally abundant in the limestones (e. g., Igo & Kamikawa, 1998) . These fossil corals have not yet been fully described.

The Kanoyama Limestone outcrops in the rural mountainous region of Nakazato Village, Tano County in Gunma Prefecture (Fig. 1). This area is located in the classical field of the so-called Chichibu Paleozoic System, which was selected as one of the standard sections of the Japanese Paleozoic formations (e. g., Fujimoto, 1936). The present authors erroneously applied the name of the Kanosan Limestone in Adachi and Igo (1998). The name of this lithostratigraphic unit denotes the name of mountain, Kanoyama, hence we replace the Kanoyama Limestone instead of the Kanosan Limestone in this paper. Previously, several geologists (e. g., Takaoka, 1966) tried to study the limestone, but they were prevented by rugged steep limestone cliffs surrounding the ridge from the detailed field survey. Their reports were remained almost as a reconnaissance work in the Kanoyama Limestone. Recently, however, the limestone has been actively quarried by the Chichibu Mining Co. Ltd. for raw materials of Portland Cement manufacture, and extensive opencuts have been appeared in the top of this limestone ridge (Fig. 2). The limestone of which length is about 2 km and the maximum width is about 500 m. It generally strikes directions of NW–SE to E–W and dips S or N in high angles. The limestone shows the complicated geologic structure by faulting, and is mostly massive or thickly

[1)] Department of Geology and Paleontology, National Science Museum, Tokyo
国立科学博物館地学研究部
[2)] Institute of Geoscience, The University of Tsukuba
筑波大学地球科学系
* Corresponding author: 3–23–1, Hyakunin-cho, Shinjuku-ku, Tokyo, 169-0073 Japan
E-mail: igo@kahaku.go.jp
連絡先：169-0073 東京都新宿区百人町 3–23–1

bedded, commonly light gray to white with dark gray intercalations in places. Bioclastic facies consisting of crinoid fragments is predominate in the limestone. Calcareous algae, foraminifers, rugose corals, brachiopods, bryozoans, and other calcareous organic debris are concentrated in places. Adachi and Igo (1998) preliminary showed that the limestone yields the fusulinacean species indicating the latest Carboniferous to Early Permian (Kasimovian to Sakmarian) including the C/P boundary. Among which, they described *Sphaeroschwagerina sphaerica gigas* (Scherbovich) that has long been known as an important age diagnostic subspecies (late Asselian) in the Moscow–Uralian to Tethyan Realms.

Paleontological Notes

We have collected many coralla of rugosans from various levels of the Kanoyama Limestone. Of which three interesting new species, *Geyeronaotia rodriguezi*, *Akagophyllum joshuense*, and *Yokoyamaella* (*Yokoyamaella*) *yamagiwai* are described here. Furthermore, we discuss some paleontological problems including the occurrence of coralla in the field and the taxonomic status of the rugosans.

The first mentioned new species, *Geyeronaotia rodriguezi*, is particularly abundant in *Carbonoschwagerina*-bearing limestones (upper Gzhelian) and shows an interesting mode of occurrence. The genus *Geyeronaotia* has been known to occur only in the Kasimovian of the

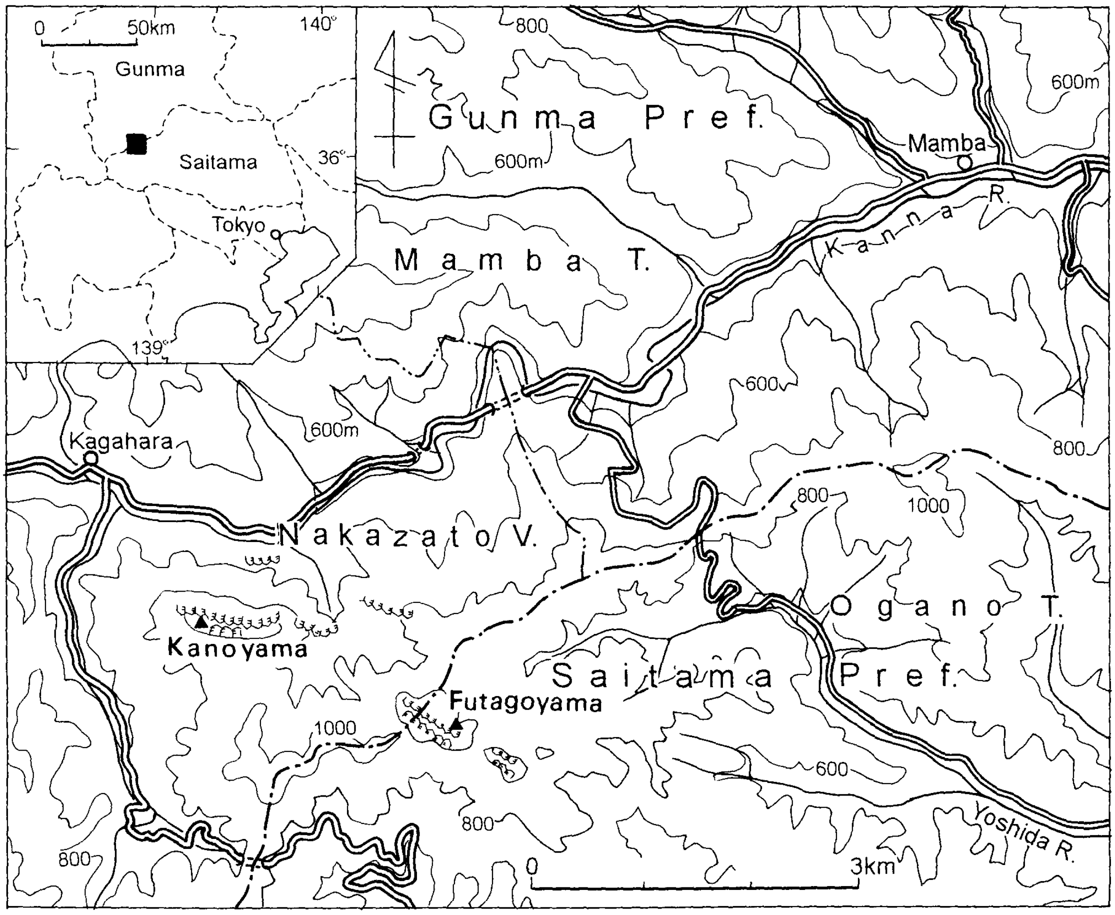
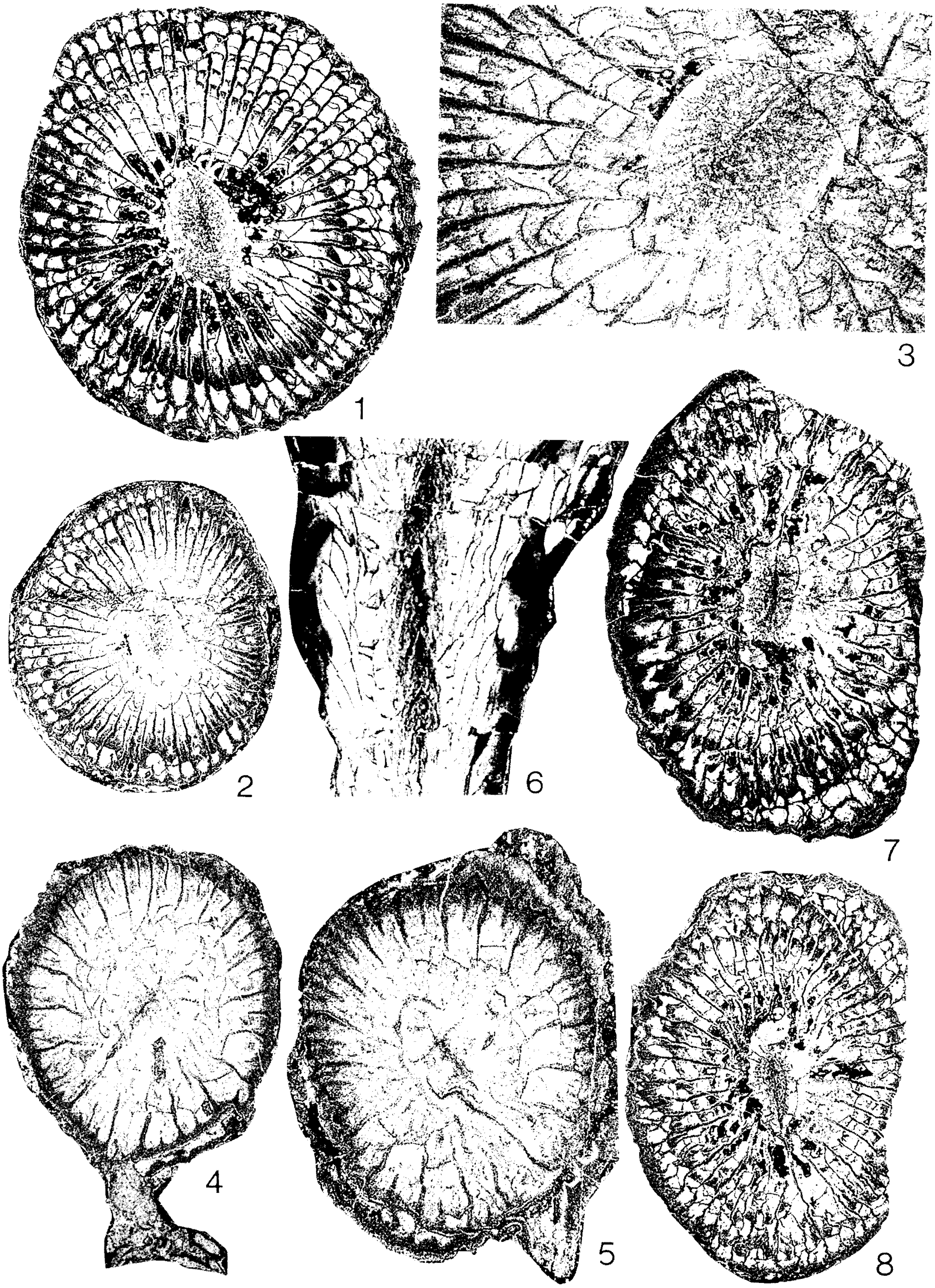


Fig. 1. Map showing the location of Mt. Kanoyama, Nakazato Village, Gunma Prefecture.

Fig. 2. Photo showing opencut mining at the sumbmit of Mt. Kanoyama in 1999.

Cantaburian Mountains in northern Spain (Rodriguez, 1984; 1985), hence the present occurrence of this genus outside of Spain seems to be the first record. There are, however, some inextricable taxonomic problems in these geyerophyllid corals. Rodriguez (1984) assigned the genus *Geyeronaotia* to the family Geyerophyllidae Minato, 1955, which represents an important group of the rugose coral fauna in the Upper Carboniferous to basal Permian of the world. After the proposal of this family by Minato (1955), its classification has been repeatedly discussed and revised by many specialists (de Groot, 1963; Hayasaka & Minato, 1966; Minato & Kato, 1967; Rowett & Kato, 1968; Cocke & Cocke, 1969; Cocke, 1970; Minato & Kato, 1975; Rodriguez, 1984, 1985; Boll, 1985; Wu, 1985; Wu & Zhao, 1989). Among these studies, Rodriguez's (1985) opinion seemed to be appropriate for the classification of these geyerophyllid corals, because he examined in detail the microstructure of septa and columella, and the ontogenetic change of coralla in the main genera of the family. The genus *Geyeronaotia* is characterized by a solid columella consisting of a medial plate, several septal lamellae, and axial tabellae, which are considerably dilated by stereoplasmic deposits. As the generic name denotes, it has commonly naotic dissepiments (also called naotic septa) but lacks well-developed lonsdaleoid dissepiments. Rodriguez (1984, 1985) pointed out that the presence of naotic dissepiments in *Geyeronaotia* is one of the important criteria to distinguish from the genus *Kionophyllum* Chi, 1931. Moreover, he considered that the genus *Geyerophyllum* Heritsch, 1936 is a junior synonym of *Kionophyllum*.

Previous to the Rodriguez's study, the presence of naotic dissepiments or septa was already discussed by Kato and Minato (1975), who emended the family Pseudopavonidae Yabe, Sugiyama and Eguchi, 1943 and pointed out that the naotic dissepiments are present in the genus *Amygdalophyllidium* of the family. Kato and Minato (op. cit.) explained the naotic dissepiments in broad sense a kind of lonsdaleoid dissepiments.

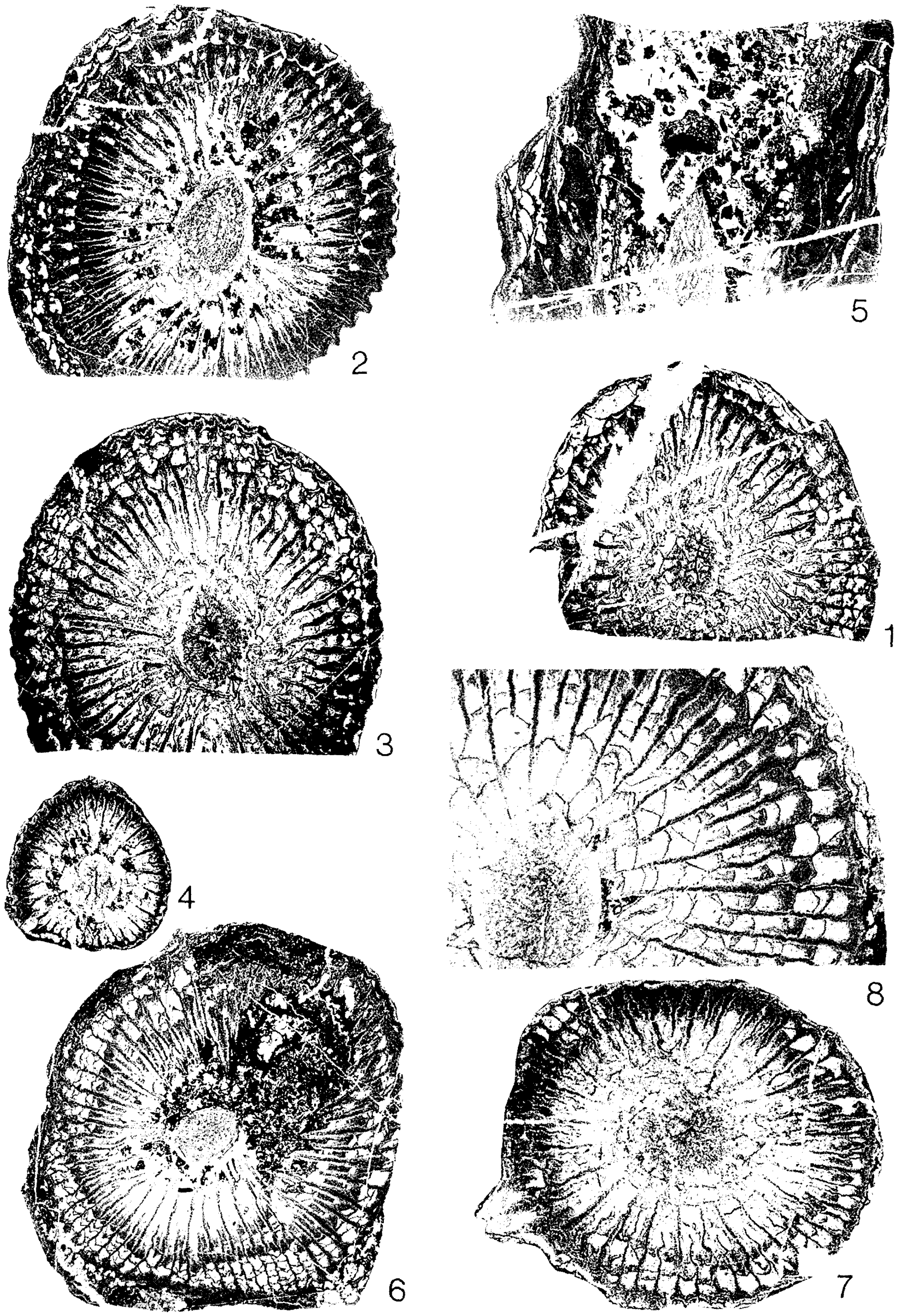

1
2
3
4
5
6
7
8

Shortly before the Rodriguez's erection of *Geyeronaotia*, Guo (1983) enacted a new genus *Lomaphyllum* from the uppermost Carboniferous of southern Dahinganling (Great Khingan Mountains), northeastern China. The type species of this genus, *Lomaphyllum cancellatum* Guo, 1983, has well-developed naotic dissepiments. Wu (1985) also reported the presence of similar naotic dissepiments in a geyerophyllid coral, *Axolithophyllum squamatum* Wu, 1985 collected from the Maping Limestone (uppermost Carboniferous) of Guizhou in south China. Wu (1987) also erected two new genera, *Nothophyllum* and *Liuzhaiphyllum*, from the Asselian of Guangxi, south China. These new genera are compound corals with naotic septa in places. Subsequently, Wu and Zhao (1989) redescribed *Axolithophyllum squamatum* Wu, 1985 and enacted two other *Axolithophyllum* species having naotic septa from the Maping Limestone. They also pointed out that the naotic dissepiments are present in their new species, *Paracarruthersella magnicolumella* Wu and Zhao, 1989. The genus *Paracarruthersella* was proposed by Yoh (1961) also from the Maping Limestone of Kwangsi in south China, but he did not mention the presence of naotic septa in the type species of *Paracarruthersella*, *P. bryocolumella* Yoh, 1961. The above mentioned Chinese studies engendered the problem that the presence or absence of naotic dissepiments in these geyerophyllid corals does not have any value to distinguish the genus, and it merely indicates variability of dissepimentarium. These Chinese studies, however, were not familiar in western countries because most of the papers were written in Chinese language. Recently, another scheme of taxonomy including the geyerophyllid and waagenophyllid corals has been presented by Xu *et al.* (in Lin *et al.*, 1995) in their comprehensive Chinese textbook. They proposed the suborder Protonaticophylina including three families, of which the family Protonaticophyllidae includes some geyerophyllid genera with well-developed naotic dissepiments. They enumerated the following genera as the member of this family; *Protonaticophyllum*, *Axolithophyllum*, *Pseudoaxolithophyllum*, *Qinglongshanophyllum*, *Naticophyllum*, *Lonsdaleoides*, and *Lomaphyllum*. Furthermore, they included *Thomasiphyllum*, *Qiubeiphyllum*, *Tanbaella*, *Lomglinophyllum*, *Stilbophyllum*, *Parapavona*, *Copia*, and *Omiphyllum* in this family. Some of them had been assigned to the family Waagenophyllidae by Minato and Kato, 1965. On the other hand, the geyerophyllid corals lacking naotic dissepiments such as *Kionophyllum*, *Paracarruthersella*, *Darwasophyllum*, *Amygdalophylloides*, and others were retained in the family Geyerophyllidae. The Chinese authors (Xu *et al.*, in Lin *et al.*, 1995), however, did not refer the Rodriguez's previous proposal.

As will be described later, the development of naotic dissepiments in our present new species is probably more or less controlled by ecological habitat. The surface of coralla in *Geyeronaotia rodriguezi* is circumscribed commonly by synbiotic algal mats. Among the present material studied, the specimens thickly lined with algal mats tend to have well-developed naotic dissepiments.

Cocke and Cocke (1969) and Cocke (1970) pointed out the similar ecological influence on the development of dissepimentarium, the external shape of corallites, and the growth of corallum in North American Pennsylvanian geyerophyllid corals. They studied many specimens collected from the Midcontinent region including Iowa, Kansas, and Missouri and interpreted that the coral species

← Fig. 3. *Geyeronaotia rodriguezi* Igo and Adachi, sp. nov. 1–6, holotype (IGUT 8090). 1, transverse section (late ephebic stage), ×4; 2, transverse section (ephebic stage), ×3; 3, enlarged part of axial area of specimen illustrated in 2, ×7; 4, 5, transverse sections (neanic stage), ×7, ×10, respectively; 6, longitudinal section (ephebic stage), ×4; 7, 8, paratype (IGUT 8091), transverse sections (late ephebic stage), ×4, ×3, respectively.


2
5
1
3
4
8
6
7

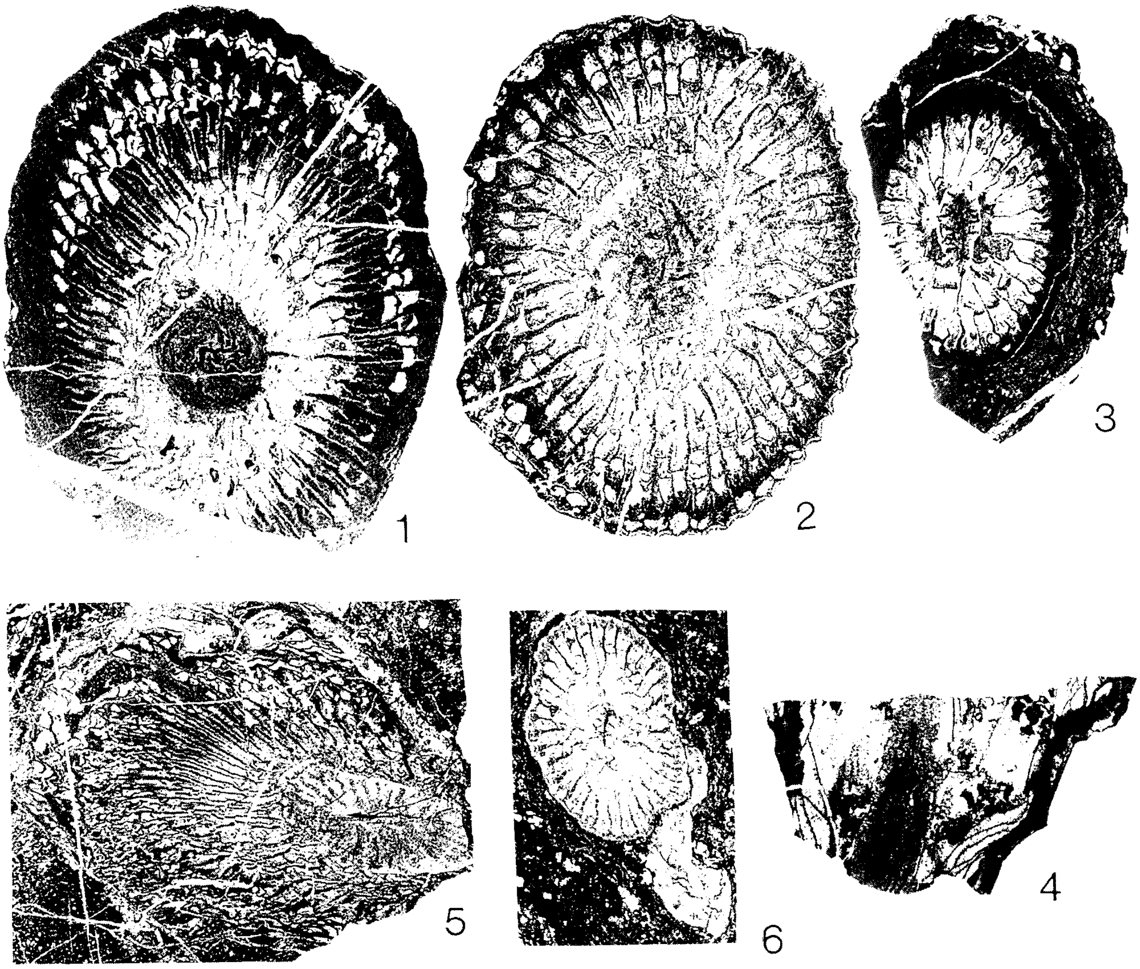


Fig. 5. *Geyeronaotia rodriguezi* Igo and Adachi, sp. nov. 1, 2, (IGUT 8095, 8094), transverse sections of crushed specimens (ephebic stage), × 4; 3, (IGUT 8098), transverse section (early ephebic stage), × 4; 4, (IGUT 8097), longitudinal section, × 4; 5, 6, (IGUT 8096), 5, transverse section (late ephebic), × 3; 6, transverse section (late neanic stage), × 4.

represent a broad spectrum of morphological types. They criticized the previously known geyerophyllid genera (*Lonsdaleoides*, *Carinthiaphyllum*, *Carniaphyllum*, *Axolithophyllum*, *Koninckocarinia*, and *Amygdalophylloides*) and concluded that the genera could be placed in synonymy with *Geyerophyllum*. In another word, they concluded that the family Geyerophyllidae is only represented by *Geyerophyllum*.

Rodriguez (1985) dissented from this view and insisted the Cockes' classification as oversimplification. Similar morphological variations, in particular the development of naotic dissepiments, reported in North American materials are also recognized in our species. On the basis of our present material, however, we defer to the Rodriguez's conclusion and assume that the presence of

← Fig. 4. *Geyeronaotia rodriguezi* Igo and Adachi, sp. nov. 1–5, paratype (IGUT 8092), 1–3, transverse sections (ephebic stage), × 3; 4, transverse section (neanic stage), × 4; 5, longitudinal section (late ephebic or gerontic stage), × 4; 6, 7, paratype (IGUT 9093), 6, transverse section (late ephebic or gerontic stage), × 3; 7, transverse section (late neanic stage), × 4; 8, enlarged part of axial area of specimen illustrated in Fig. 3- 2, × 7.

naotic dissepiments has the taxonomic value as an important generic criterion. Moreover, other diagnostic characters are recognized in our *Geyeronaotia* species as described later. We consider that the genus *Geyeronaotia* is a descendant of *Kionophyllum* (=*Geyerophyllum*) and belongs to the family Geyerophyllidae Minato, 1955 as suggested by Rodriguez (1985), and the genus represents an ancestral stock of certain genera, such as *Pseudoaxolithophyllum* and *Protonaticophyllum*, which should be classified as the member of the family Protonaticophyllidae Xu and Chen, 1987.

Another coral species described here is *Akagophyllum joshuense*. This coral is a new fasciculate species and its coralla appear repeatedly as large tabular colonies on the quarry faces as well as floors during mining operation. These colonies have various sizes of which largest one observed probably covers an area of more than 5 m^2 and 1.5 m thick, however, they are a monotonic species association. The limestone embedding these large colonies is characteristically pale gray and composed of darker lime mud and fine-grained calcite fragments of calcareous organisms showing fine lamination. These colonies may represent a part of the autochthonous patch reef.

Minato and Kato (1965) erected the genus *Akagophyllum* to represent the family Waagenophyllidae and assigned seven species including two new species. They pointed out that the range of this genus is restricted within the Lower Permian (includes probably the present definition of the Asselian, Sakmarian, and Artinskian). Subsequently, several new species have been reported from China (e. g., Guo, 1980, 1983; Wang & Zhao, 1998) of which Guo's new species, *A. dahezhenense*, *A. neimongolense*, and *A. polygonalis* occur in the uppermost Carboniferous in northeast China. The present new species of *Akagophyllum* occurs in the upper Gzhelian to lower Asselian, hence the genus makes its debut in the uppermost Carboniferous. As will be described later, this species indicates primitive features in size of corallites, number of major septa, and variously constructed columella. It also shows interesting corallum increase. The present new species is the oldest one among the previously reported *Akagophyllum* species and may represent an ancestral stock of this genus as well as the genera in the family Waagenophyllidae.

Yokoyamaella (*Yokoyamaella*) *yamagiwai* is the last mentioned one that occurs as fragmented coralla in calcarenite composed of crinoid fragments. The specimens were transported from their life site and embedded in encrinal limestone. The genus *Yokoyamaella* was enacted by Minato and Kato (1965) and several species have been known to occur in Japan, China, and other Tethyan realms. Our present specimens are not so well preserved, but they permit their assignment to a new species. This new species shows primitive features compared with those of other known species. Moreover, the stratigraphic position of the coral indicates the basal Permian, hence this species may represent the earliest species in the previously known *Yokoyamaella* species.

Repository: The specimens described in this paper are housed at the Paleontological Collection of the Institute of Geoscience, The University of Tsukuba with prefix IGUT.

Description of Species

Family Geyerophyllidae Minato, 1955

Genus *Geyeronaotia* Rodriguez, 1983

Geyeronaotia rodriguezi Igo and Adachi, sp. nov.

(Fig. 3: 1–8, Fig. 4: 1–8, Fig. 5: 1–7)

Diagnosis: A small *Geyeronaotia* with long dilated major and minor septa; distinct thick inner

wall; concentric, angulate, and naotic dissepiments; solid columella constructed by consolidated medial plate, radiating septal lamellae, and axial tabellae. Rejuvenescence common.

Description: Corallum small, solitary; external shape of corallite narrowly conical to subcylindrical. Calyx deep with boss of axial column on bottom. Externally, longitudinal ribbing prominent. Diameters of mature corallites range from 12.0 to 18.0 mm; lengths reach 20.0 to 30.5 mm so far as preserved.

Transverse section: In ephebic stages, external wall thick with prominent septal furrows and interseptal ridges with angulate crests. Major septa number 30 to 31, long, attain about 3/4 radius of corallite, reach peripheral of columella but not directly joined, zigzag in dissepimentarium, and distally pointed. Cardinal septum, directly connected to medial plate of columella or separated in places. Disconnection of cardinal septum and medial plate seems to be caused by mechanical state of preservation. Cardinal septum and other major septa entirely withdraw from central area of corallite in late ephebic and gerontic stages. Minor septa slightly thinner than major septa, regularly alternated with majors, about 1/2 to 2/3 of major septal length, and thickened in dissepimentarium as well as tabularium. These thickened septa along periphery of tabularium form prominent inner wall. Septa interrupted by both small lonsdaleoid and naotic dissepiments, and discontinuous with outer wall. Microstructure of septa trabecular in most specimens, but diffuso-trabecular rarely discernible.

Columella oval in outline, longer across 3.3 to 6.3 mm, shorter ones 2.0 to 3.3 mm, about 1/3 to 1/4 corallite diameter, with prominent radiating edges; constructed by long medial plate, about 20 radiating septal lamellae, and a few axial tabellae. These elements thickened by streoplasmic deposits. Furthermore, stereoplasmic rind surrounds periphery of columella in most specimens. In some compressed specimens, septal lamellae in columella strongly contorted.

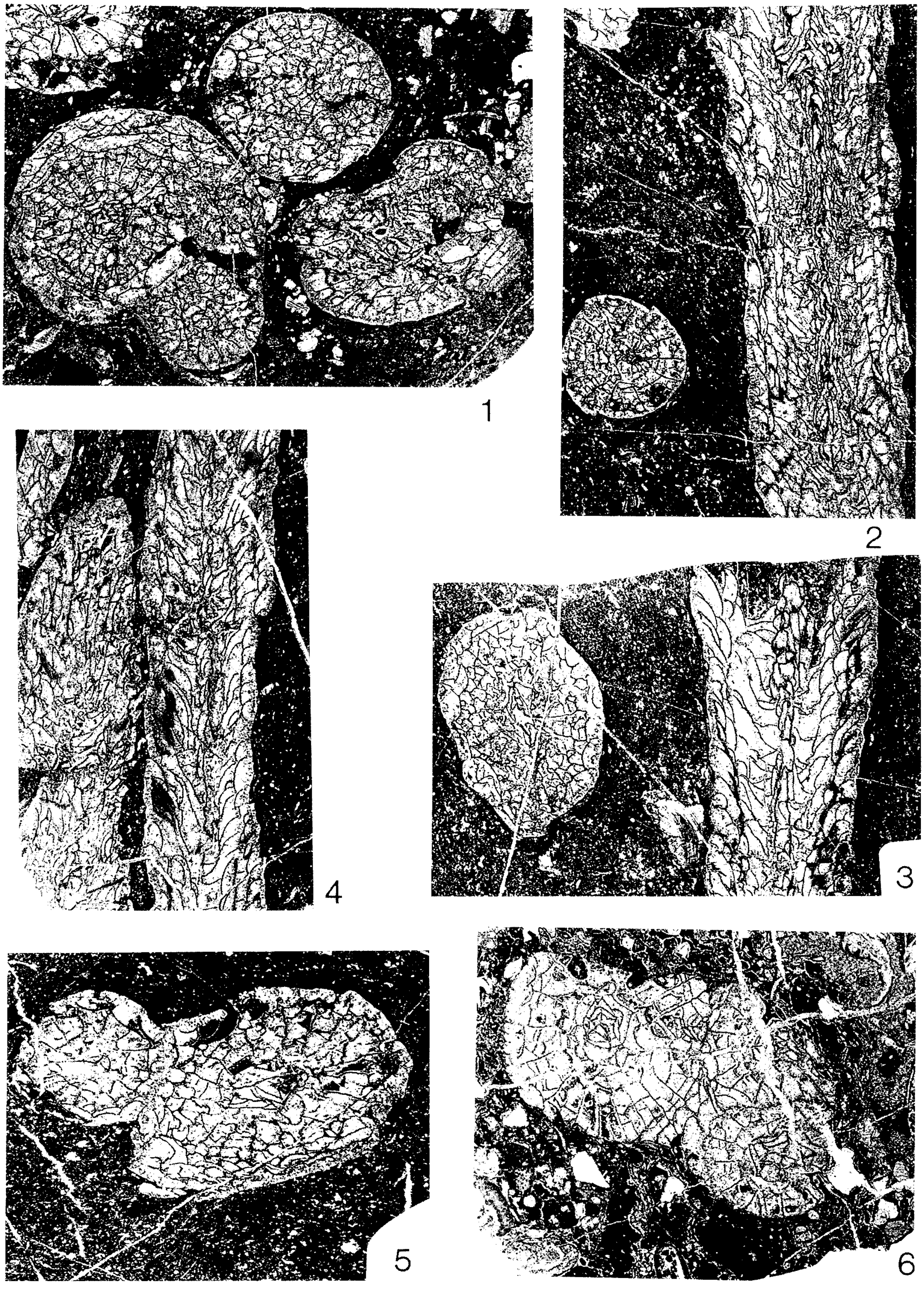
Dissepimentarium variable in width, commonly 1/2 to 1/3 of corallite radius. Dissepiments concentric in inner; outer ones peripherially convex with sharp angulate crests. Closely spaced naotic dissepiments form narrow peripheral band. Corallites covered with thick algal mats commonly have well developed naotic dissepiments. Tabularium occupied by widely spaced cut-edges of tabulae.

In neanic corallites at diameter between 3.7 to 5.0 mm, external wall and all septa extremely thick proximally; 20 to 22 major septa present. Minor septa short, 1/2 to 1/3 of major septal length, and thorn-like in places. Dissepiments entirely absent or poorly developed. Columella solid, large in comparison with corallite diameter, consists of thick medial plate that represents direct extension of cardinal septum; radiating septal lamellae, and circumscribed by stereoplasmic rind. In early neanic stages, rhopaloid cardinal septum constructs simple axial structure.

Longitudinal section: Thick outer wall shows rugosity. Dissepiments large, both globose and elongated; generally 5 to 6 tiers of them construct rather broad dissepimentarium. Tabularium consists of clinotabulae in outer; anastomosed, horizontal, and also sagging transverse tabulae appear in inner narrow zone. Columella stout, cylindrical, consists of sinuous medial plate, cone-in-cone axial tabellae, and septal lamellae.

Rejuvenescence common throughout growth stages.

Remarks: The present new species is similar to *Geyeronaotia hispanicus* Rodriguez, 1984 in corallite size, number of septa, microstructure of septa, and configuration of columella. Our new species has a thicker inner wall, larger diameter of columella in comparison with corallite diameter, longer minor septa, more numbers of septa, and less development of naotic dissepiments than those of *G. hispanicus*.


1
2
4
3
5
6

Geyerophyllum sp. cf. *G. broilii* Heritsch, 1936 and *G. garntlensis* described by Cocke (1970) from the Pennsylvanian of Kansas are superficially similar to the new species, but the latter has a larger corallite, more numbers of major septa, different configuration of columella, and less development of naotic and lonsdaleoid dissepiments.

Geologic age: Gzhelian (Late Carboniferous).

Material: Reg. nos. IGUT 8090 (holotype), IGUT 8091, 8092, 8093, 8094, 8095, 8096, 8097, 8098 (paratypes)

Family Waagenophyllidae Wang, 1950

Genus *Akagophyllum* Minato and Kato, 1965

Akagophyllum joshuense Igo and Adachi, sp. nov.

(Fig. 6: 1–6, Fig. 7: 1–6, Fig. 8: 1)

Diagnosis: A species of *Akagophyllum* with thick external wall; 17 to 19 major septa, well developed lonsadaleoid dissepiments, and irregularly constructed axial structure. Increase peripheral.

Description: Corallum fasciculate, phaceloid; corallites slender, cylindrical, subparallel, and closely spaced; contact with each other during branching by peripheral increase. External surface of coralla unobservable.

Transverse section: Corallites circular to subcircular, diameter 5.0 to 7.5 mm, average about 6.0 mm in mature stages. Major septa radially disposed, number 15 to 19, mostly 18; long, nearly reach axial column but not directly joined. Counter septum long and united with medial plate of axial structure in some corallites. Minor septa about 1/2 length of majors and penetrate tabularium. These septa more or less dilated and zigzag. Septal microstructre diffuso-trabecular.

Axial structure irregularly and loosely constructed and variable in complexity. Medial plate curved or sinuous, not commonly developed, but clear in places as elongation of counter septum. Septal lamellae less numerous and radiating. Axial tabellae irregularly encircling or straight in places and two or three of them construct loose spider web structure with other elements. Dissepimentarium well developed, two to four tiers of various sized lonsdaleoid dissepiments in periphery of corallite; also concentric and herringbone interseptal dissepiments variously developed.

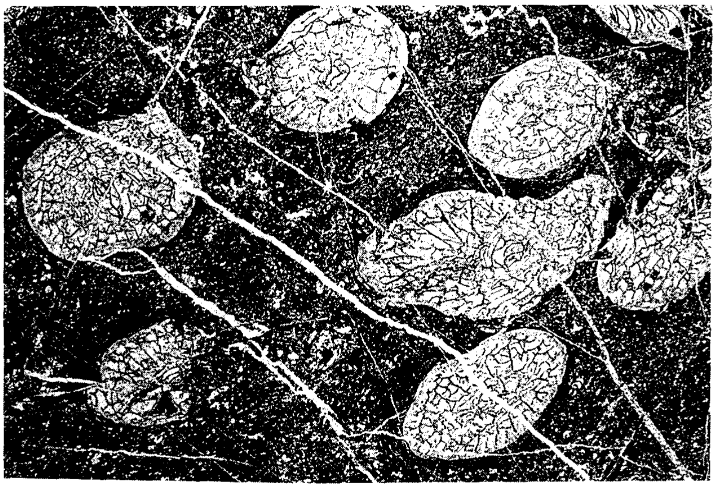
In neanic corallites, at diameter of 3.0 to 4.0 mm, major septa number 10 to 14, and minor septa alternated. Counter septum commonly connected to medial plate of loosely and simply constructed axial column. Lonsdaleoid dissepiments various in development. Interseptal dissepiments a few rows of concentric and rarely herringbone pattern.

Longitudinal section: Slender corallites show triareal arrangement of dissepimentarium, tabularium, and axial column. Peripheral dissepimentarium consists of one to three tiers of large globose dissepiments facing inward. Tabularium narrow, composed of outer clinotabulae and subhorizontal to concave inner periaxial tabulae. Axial column stout, slightly sinuous, and variously constructed. Medial plate sinuous, well developed or entirely lacking. Axial tabellae dense and steeply elevated. Septal lamellae developed in places.

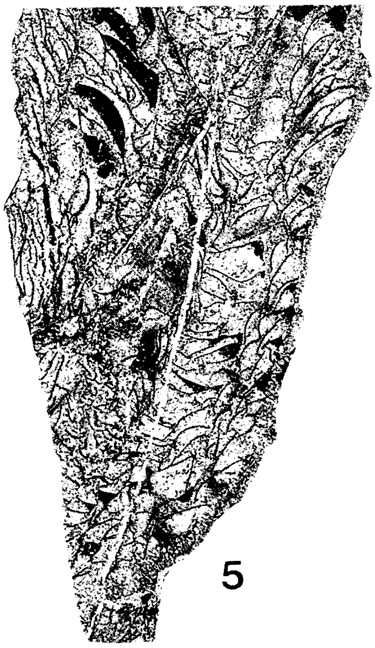
Remarks: The present new species represents primitive characters in configuration of columella,

← Fig. 6. *Akagophyllum joshuense* Igo and Adachi, sp. nov. 1–6, holotype (IGUT 8101), 1, transverse section of corallites showing peripheral increase; 2, 3, longitudinal and transverse sections of corallites; 4, longitudinal section of corallites; 5, transverse section of branching corallites; 6, transverse section of branching corallites showing cerioid appearance, all × 4.

6

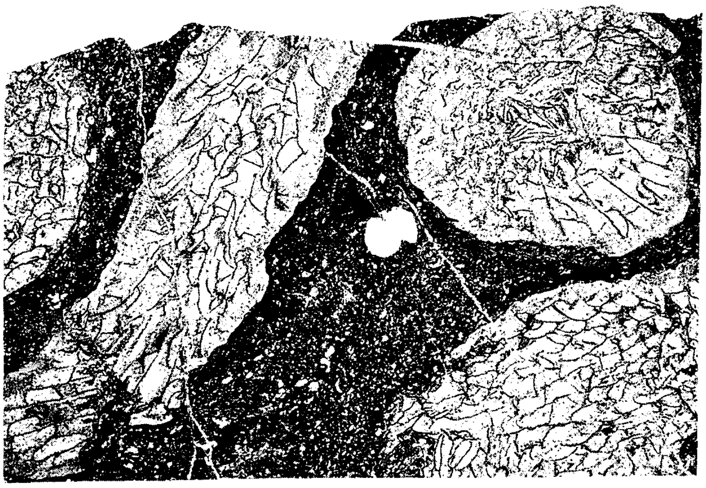


1



5

2



4

3

small size of corallites, numbers of major septa, and development of lonsdaleoid dissepiments. Furthermore, this new species shows a unique character compared with the previously described species of *Akagophyllum*. Corallites in this species increase peripheral; two or three daughter corallites appear in the protocorallite. These corallites are separated by common walls and show a cerioid appearance during budding.

Akagophyllum hasegawai Minato and Kato, 1965 slightly resembles our new species in the construction of columella and size of corallites, but the latter differs from the former in well developed lonsdaleoid dissepiments and corallite increase as mentioned above. *A. neimongolense* Guo, 1983 described from southern Dahinganling, northeastern China resembles our new species, but the latter has a fewer numbers of major septa in the corresponding corallite diameter, longer major septa, and more well developed lonsdaleoid dissepiments.

Geologic age: Latest Gzhelian to earliest Asselian (Late Carboniferous to earliest Permian).

Material: Reg. nos. IGUT 8099 (holotype), IGUT 8100, 80101(paratypes).

Genus *Yokoyamaella* Minato and Kato, 1965

Subgenus *Yokoyamaella* Minato and Kato, 1965

Yokoyamaella* (*Yokoyamaella*) *yamagiwai Igo and Adachi, sp. nov.

(Fig. 8: 2–7)

Diagnosis: A species of *Yokoyamaella* (*Yokoyamaella*) with small polygonal corallites, poorly developed lonsdaleoid dissepiments, loosely constructed columella, and discontinuous wall.

Description: External feature and entire size of corallum unknown. Corallum compound, massive, cerioid but aphroid in places.

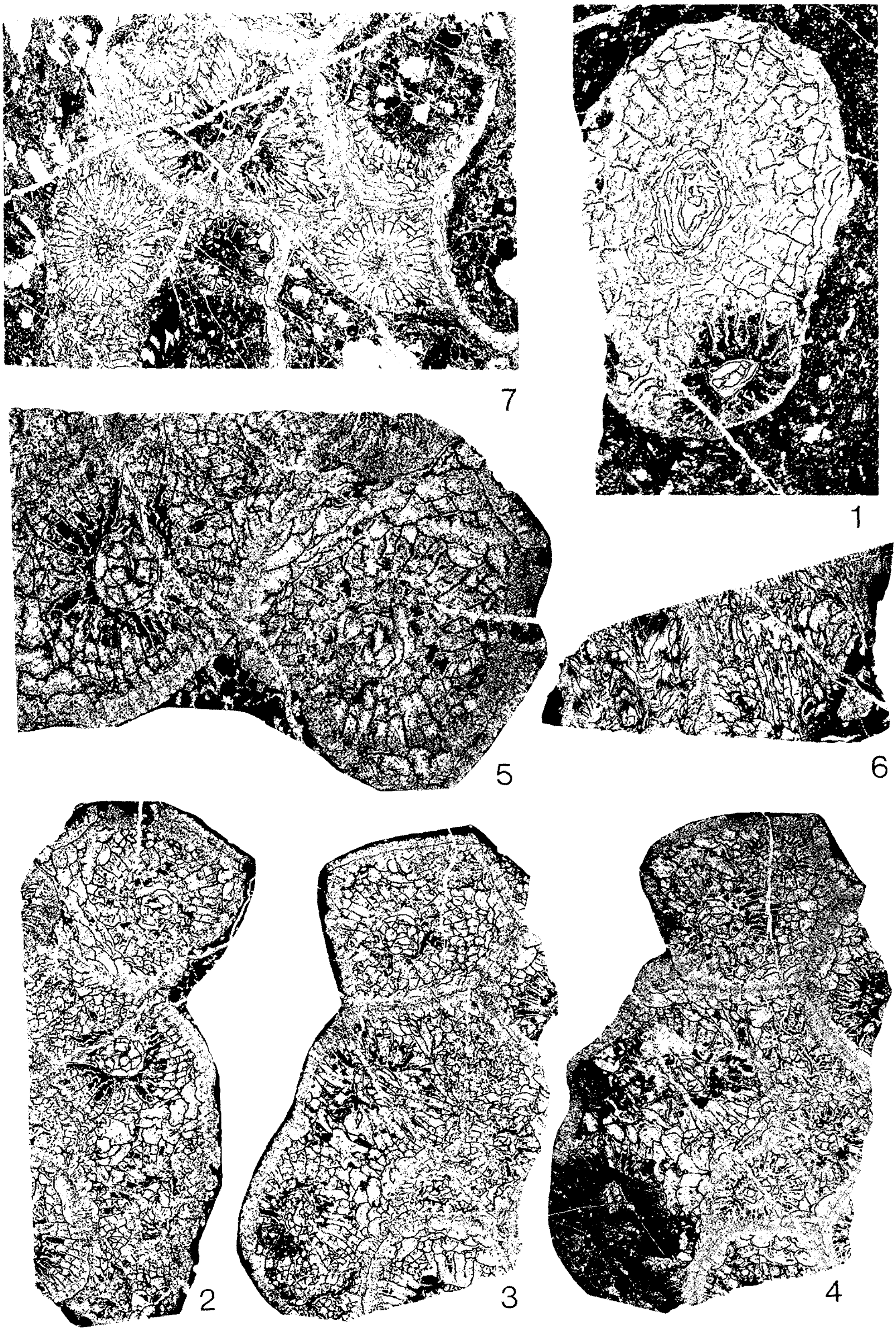
Transverse section: Mature corallites irregularly polygonal, five to six sided, and about 7.0 to 8.0 mm in diagonal. Wall originally thin, strengthened by thick mural septa, completely joining each other. Boundary between neighboring corallites indicated by thin clear calcite line and also dark line, which may represent fracture line and cemented by dark calcareous mud.

Septa two orders, major and minor ones in alternation; both thickened by stereoplasmic deposits. Major septa number 17 to 19, long, reach axial structure, but not united with each other in mature corallites. Counter septum joined to medial plate or septal lamellae in places. Minor septa long, slightly shorter than majors. Microstructure of septa mostly diffuso-trabecular.

Axial structure oval in outline, about 1.5 to 2.0 mm in diameter, loosely constructed by medial plate, two or three circumscribing axial tabellae and several radiating septal lamellae. These elements, in particular medial plate, thickened by stereoplasmic deposits. In early neanic corallites, axial structure consists of thickened medial plate continued from counter septum. Lonsdaleoid dissepiments large, globose, and irregular in shape, and well developed in peripheral area of mature corallites.

In longitudinal section, wide dissepimentarium, narrow tabularium, and central wide axial structure evident. Axial structure consists of thick flexuous medial plate, overlapping dome-shaped axial tabellae, and a few cut-edges of septal lamellae. Dissepimentarium composed of globose to hemicircular dissepiments, which mostly facing inward. Elongate dissepiments present but not typical.

◂ Fig. 7. *Akagophyllum joshuense* Igo and Adachi, sp. nov. 1–6, paratype (IGUT 8099), 1, transverse section of corallites, × 3; 2, transverse section of corallites, × 5; 3, transverse section of corallite showing early stage of pheripheral increase, × 5; 4, transverse and longitudinal sections of corallites, × 5; 5, longitudinal section of corallite, × 5; 6, transverse section of corallite showing peripheral increase, × 4.


7
1
5
6
2
3
4

Tabularium consists of inner narrow concave tabulae and inclined clinotabulae. These elements more or less thickened by stereoplasmic deposits. Increase of corallite very commonly observed as peripheral; two or three new doughter corallites appear as aphroid or partly separated by thin wall of mural septa.

Remarks: This new species is slightly similar to *Yokoyamaella* (*Y.*) *yokoyamai* (Ozawa) described from several localities in Japan, but the former has a fewer numbers of major septa, more well developed lonsdaleoid dissepiments, and a simply constructed columella.

Yokoyamaella (*Y.*) *matsunagiense* (Yamagiwa, 1962) from the Atetsu Limestone was synonymized with *Y.* (*Y.*) *yokoyamai* by Minato and Kato (1965), and is also distinguished from the present species by the above mentioned differences. The present new species and *Y.* (*Y.*) *tertioseptata* (Yokoyama, 1960) are allied species, but the latter species said to have the tertiary septa, and has a thicker wall compared with the former.

Geologic age: Asselian to Sakmarian (Early Permian).

Material: Reg. nos. IGUT 8013 (holotype), IGUT 8012 (paratype).

Acknowledgments

We thank Professor Hisaharu Igo of Tokyo Gakugei University for his collaboration in the field and laboratory. We also thank Messrs. Masatoki Yanase, Yoshiyuki Iwasaki, Keizo Kobayashi, and other staff of the Chichibu Mining Co. LTD. for their kind help in the field.

要　　約

群馬県多野郡中里村から埼玉県秩父郡両神村にかけての奥秩父地方には双子山，白石山，叶山などをつくる石炭系・ペルム系の石灰岩岩体が古くから知られているが，いずれも断崖絶壁の急峻な山体で，登山道がやや整備されている双子山の一部を除いては，詳細な研究は進んでいない．近年最も急峻な山体の叶山は山頂から大規模な採掘が行われるようになって，層位学的ならびに古生物学的な研究が可能になってきた．著者らの予察的な研究結果では，この岩体には石炭系最上部からペルム系最下部の層準が多く，紡錘虫を始め多くの化石を含むことが明らかになってきた．今回はこの石灰岩で認められた石炭系・ペルム系境界付近から採集したサンゴ化石3新種，*Geyeronaotia rodriguezi*, *Akagophyllum joshuense*, *Yokoyamaella* (*Yokoyamaella*) *yamagiwai* を記載した．*Geyeronaotia* 属はこれまでその模式種 *hispanica* がスペイン北部のカンタブリア山地の上部石炭系から報告されているにすぎない．本属は *Geyerophyllum*, あるいは同属ともみられる *Kionophyllum* に酷似するが"naotic dissepiments"あるいは"naotic septa"とよばれる特徴的な構造をもつことから提唱された．しかし，これと前後して中国の研究者によって同様な構造を有する新しい類似属や，新しい科の提唱などが行われ，現時点でもかなりの混乱が生じている．本論ではこれら一連の研究をレビューした結果 *Geyronaotia* 属ならびに Geyerophyllidae 科を有効として採用した．新種 *G. rodriguezi* は模式種より"naotic dissepiments"の発達が貧弱で，やや原始的ともみられるが，産出層準は若干上位とみられる．*Akagophyllum* は Waagenophyllidae 科の中では原始的で，我が国はもとより，中国などからもよく知られているペルム紀初期の群体サンゴである．本新種はこれまで報告された多くの種の中でも原始的で，この属の祖先型である．群体成長が特異で親の corallite の中に"peripheral increase"として2ないし3個

← Fig. 8. 1, *Akagophyllum joshuense* Igo and Adachi, sp. nov., paratype (IGUT 8099), transverse section of corallite showing peripheral increase, ×7; 2–7, *Yokoyamaella* (*Yokoyamaella*) *yamagiwai* Igo and Adachi, sp. nov., 2–6, holotype (IGUT 8103), 2, 3, 4, serial transverse sections of corallum, ×3; 5, transverse section of part of corallum, ×5; 6, longitudinal section of corallum, ×3; 7, paratype (IGUT 8102), transverse section, ×3.

の"daughter corallites"が生じる．*Yokoyamaella*も本邦の下部ペルム系によく知られたWaagenophyllidae科の群体サンゴであるが，本新種も従来知られていたものよりも原始的とみられる．産出層準は前2種よりはやや上位である．我が国の石炭系・ペルム系のサンゴ化石の研究は先達の努力でかなり進展しているが，その境界付近のものは報告例がこれまで意外とすくないので，今回得られた化石は貴重である．

References

Adachi, S. & H. Igo, 1998. *Sphaeroschwagerina* (Fusulinacea) from the Kanosan Limestone in the Kanto Mountains, Gunma Prefecture, Japan. *Sci. Rep., Inst. Geosci., Univ. Tsukuba*, Sec. B, **20**: 145–167.

Boll, F. C., 1985. Rugose Korallen der Flachwasser-Fazies im oberkarbon des Kantabrischen Gebirges (Nordspanien). *Palaeontograph.*, Abt. A, **190**: 1–81.

Cocke, J. M., 1970. Dissepimental rugose corals of Upper Pennsylvanian (Missourian) rocks of Kansas. *Paleont. Contr., Univ. Kansas*, **54**:1–67.

Cocke, J. M. & N. C. Cocke, 1969. Redescription of a Pennsylvanian geyerophyllid coral species from Iowa. *Jour. Paleont.*, **43**:941–946, pl. 114.

Fujimoto, H., 1936. Stratigraphical and palaeontological studies of the Titibu System of the Kwanto Mountainlands, Part 2. *Sci. Rep., Tokyo Bunrika Daigaku*, Sec. C, **1**: 20–125, pls. 1–26.

Guo Sheng-zhe, 1980. Phyllum Coelenterata, Tetracoralla. *In* Shenyang Inst. Geol. Min. Resources (ed.), *Paleontological Atlas of Northeast China* (1) *Paleozoic Volume*, pp. 106–153, pls. 42–66. Geol. Pub. House, Beijing. (In Chinese.)

Guo Sheng-zhe, 1983. Middle and Upper Carboniferous rugose corals from southern Dahinganling (Mts. Great Khingan). *Acta Palaeont. Sinica*, **22**: 220–230, pls. 1–4. (In Chinese with English abstract.)

Groot, G. E. de., 1963. Rugose corals from the Carboniferous of northern Palencia (Spain). *Leidse Geol. Mededelingen*, **29**: 1–124, pls. 1–26.

Hayasaka, I. & M. Minato, 1966. On *Lonsdaleia nishikawai* n. sp. (On Upper Paleozoic fauna from Miharano, Hiroshima Prefecture, Japan, 2nd note). *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **13**: 273–280, pl. 33.

Igo, H. & Y. Kamikawa, 1998. Carboniferous rugose corals from the Nanmoku area, northwestern part of the Kanto Mountains, Gunma Prefecture, Japan. *Sci. Rept., Inst. Geosci., Univ. Tsukuba*, Sec. B, **19**: 29–42.

Kato, M., 1972. Permian corals of Miharano (An Upper Palaeozoic fauna from Miharano, Hiroshima Prefecture, Japan. 4th note). *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **15**: 501–512, pls. 1–2.

Kato, M. & M. Minato, 1975. The rugose coral family Pseudopavonidae. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **17**: 89–127, pls. 1–6.

Lin Bao-yu, Xu Shou-yong, Jia Hui-zhen, Guo Sheng-zhe, Ou Yuan-xuan, Wang Zeng-ji, Ding Yun-jie, Zeng Yong-yi, Yan You-yin & Chen Hua-cheng, 1995. Monograph of Paleozoic corals. Rugosa and Heterocoralla. 778 pp., 8 pls. Geol. Pub. House, Beijing. (In Chinese with English abstract and summary.)

Minato, M., 1955. Japanese Carboniferous and Permian corals. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **9** (2): 1–202, pls.1–43.

Minato, M. & M. Kato, 1965. Waagenophyllidae. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **12**: 1–241, pls. 1–20.

Minato, M. & M. Kato, 1967. On the coral genus *Carinthiaphyllum* Heritsch, with a description of *Carinthiaphyllum carnicum* Heritsch from the Carnic Alps. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **13**: 313–320, pl. 38.

Minato, M. & M. Kato, 1975. Geyerophyllidae Minato, 1955. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **17**: 1–21.

Rodriguez, S., 1984. Corales rugosos del Carbonifero del este de Autras. Departamento de Paleontologia, Facultad de Ciencias Geológiscas, Universidad Complutense de Madrid, Colecció Tesis Doctorales (109/84). 528 pp., 32 pls.

Rodriguez, S., 1985. The taxonomic status of the Geyrophyllid corals. *Acta Geol. Polonica*, **35**: 277–288.

Rowett, C. L. & M. Kato, 1968. The coral genus *Darwasophyllum* Pyzhjanov, and a related corals from S. W. Japan. *Jour. Fac. Sci., Hokkaido Univ.*, Ser. 4, **14**: 37–43, pl. 10.

Takaoka, Y., 1966. Fusulinids from the Mt. Tatoro, Mt. Kano, Mt. Futago and Mt. Shiraishi areas of the Kanto–massif, central Japan. *Bull. Chichibu Mus. Nat. History*, (13):39–70, pls. 5–16.

Wang Zhi-gen & Zhao Jia-ming, 1998. Middle Permian corals from Laibin County, Guangxi. *Acta Palaeont. Sinica*, **37**:40–66, pls. 1–4. (In Chinese.)

Wu Wang-shi, 1985. A strange form of the genus *Axolithophyllum*. *Acta Palaeont. Sinica*, **24**: 181–185, pl. 1. (In Chinese

with English abstract.)

Wu Wang-shi, 1987. A study on some Asselian corals. *Acta Palaeont. Sinica*, **26**: 149–157, pls. 1–3. (In Chinese with English abstract.)

Wu Wang-shi & Zhao Jia-ming, 1989. Carboniferous and Early Permian Rugosa from western Guizhou and eastern Yunnan, SW. China. *Palaeont. Sinica*, N. Ser. B, (24):1–230, pls. 1–63. (In Chinese with English abstract.)

Yoh Sen-sing, 1961. On some new tetracorals from the Carboniferous of China. *Acta Palaeont. Sinica*, **9**: 1–17, pls. 1–3. (In Chinese with English abstract.)